THE ANATOMICAL AND PHYSIOLOGICAL BASIS OF THE KINESIO-NEUROSES OF INFANCY AND CHILDHOOD.*

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THE knowledge of the important subject of the anatomy and physiology of early life is fragmentary and meagre in comparison to the great mass of facts which have been accumulated with reference to the adult organism. This department of medical science is a kind of " accessory system " which has followed the order of historical development. It was a matter of little moment to the ancients whether infants survived or perished. With modern civilization the value of all human life has increased—that of the child in geometrical ratio to that of the adult.

When some quaint old volume of a hundred years ago comes to hand, one realizes how much the spirit of investigation and scientific inquiry has done for medicine in the century that has passed, and how much more it will probably do in the century that is to come. Such a work is that of Rosen von Rosenstein, who was " first physician to his Swedish Majesty, and Knight of the Polar Star." He wrote so well that Dr. Andrew Sparrman translated his book, which was entitled " The Diseases of Children and their Remedies," and published it in 1776. The following is the paragraph introducing the short chapter on "Convulsions and their Ten Causes," the only chapter on nervous affections of childhood in the book:

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"The nerves of children are very sensible and irritable. They are more numerous in proportion to their bodies than those of a grown person; and as they have many juices or fluids, they are so much the more softened. They are also covered with a very thin membrane, which makes their sensations so much the greater. For this reason children are subject to startings, and these, at whatsoever time of life they occur, are called convulsions; but when the whole body is affected, and the face at the same time appears bluish, it is then called an epilepsy."

To the writers of Gerhardt's "Handbuch der Kinderkrankheiten" one is indebted for any thing like a comprehensive view of the subject. Each contributor in his turn exclaims at the lack of research in this direction. Prof. W. Henke in his article for that publication on the Anatomie des Kindesalters[1] begins with saying:

"The anatomy of childhood, or the unfolding of our organism from the state in which it was born till its full development, is strikingly little known."

Vierordt,[2] who gives the most elaborate description of the physiology of childhood to be found, makes the following statement:

"A physiology embracing the whole period of childhood has hitherto not been attempted. The writing of Emil Allix, 'Etude sur la physiologie de la premier enfance,' published in Paris, in 1867, is limited to the two first years of life." Vierordt also depicts the pressing necessity of the investigation of the physiology of this period of existence in order to solve problems, pathological and otherwise, which have so long remained without an answer.

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[1] Gerhardt's "Handbuch d. Kinderkrhtn.," ed. 1882, vol. i.

[2] Gerhardt's "Handbuch Phys. des Kindesalters."

To Soltmann, the investigator will feel especially grateful, since by experiment and pathological study he has thrown light on some of the most obscure points in connection with the subject.

Take away what has been done by these three writers, Henke, Vierordt, and Soltmann, which is comparatively recent, and there would be very little left. As has been already intimated there is no one book which deals exclusively with the anatomy and physiology of childhood. The standard works in English, French, and German on children's diseases, recognize for the most part the necessity of such a knowledge to a correct interpretation and satisfactory treatment of the diseases of early life; but have been compelled by their own limitations to dismiss it with simply alluding to certain facts in a sketchy and cursory manner.

If what has been said is true in regard to the physiology and anatomy of childhood in general, it is doubly applicable to that of the nervous system.

These prefactory statements have been made not only to display the true state of the subject, but as a *rason d'etre* for this article, which has for its aim to present such facts as can be gathered together to show that the nervous diseases peculiar to early life have an anatomical, physiological, and psychical basis, which explains why the kinesio-neuroses tetanus, convulsions, chorea, and epilepsia are most prevalent in early life.[1]

That the nervous diseases of childhood are motor is patent to the most superficial observer; but how almost exclusively motor is not perhaps realized until the statistics relating to them are reviewed. Neuroses of the sensibility are exceedingly rare before the tenth year. Valleix knew of but one example: a case of lumbago, which occurred in a child a year old. Neuralgia is a rare affection of childhood, and of adolescence as well. In 296 cases reported, only two occurred before ten years of age, and twenty-four before the twentieth year. Enlenburg,[1] in 101 cases had only six which occurred from the seventh to the nineteenth year, not one before seven. Soltmann,[2] in his observation of nearly ten thousand children, found only twenty-two with cutaneous neuralgia.

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[1] Soltmann: "Die Functionelle Nervenkrankhtn."; Gerhardt's "Handbuch d. Kinderkrankt.," p. 4, B. 17.

Convulsions are the most prevalent of nervous diseases of the infant. West[3] makes the statement that seventy-four per cent. of all deaths which take place during the first year of existence are from diseases of the nervous system. In the next two years they are one third as frequent, from ten to fifteen they come less than three per cent., and over fifteen one per cent. The Registrar-General's report, London, 1849, records the death by convulsions of 1,135 males, 1,123 of whom were under five years of age; and of 928 females, 890 were under five years.

The next great motor neurosis of children is epilepsia. By far the greater number of attacks of this disease occurs before puberty. According to Beau, among 210 there were 191. Hasse, among 995 reports 757 as recurring before the twentieth year; Bouchut and Cazanvieihl, among 66 give 40 as occurring during that period. The proportion to the various ages can be seen at glancing at the subjoined tables.

Bouchut and Cazanvieihl, 66 Cases.		Beau, 210 Cases.	
Age at time of Outbreak.	No. of Cases.	Age.	No. of Cases.
0—5 yrs.	18	6—0 yrs.	39
10—15 "	22	6—12 "	43
15—20 "	10	12—16 "	49
20—25 "	5	16—20 "	17
25—30 "	4	20—30 "	29
30—35 "	1	30—40 "	12
40—60 "	4	40—61 "	21

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[1] " Handboch d. Nervenkhtn."

[2] *Loc. cit.*, p. 296.

[3] West: " Diseases of Children."

Hasse, 995 Cases.

Age.	No. of Cases.	
—1 yr.	87	Quoted from Gerhardt's "Kinderkrhtn." Soltmann: "Die functionellen Nervenkrkhtn."
2—10 yrs.	306	
10—20 "	364	
20—30 "	111	
30—40 "	59	
40—50 "	51	
50—60 "	13	
60—70 "	4	

The third great motor disease of childhood is chorea, which occurs chiefly from the seventh to the fourteenth year. Its distribution through the years of childhood is shown in the following tables, as well as the sex distribution:

Rufz, 189 Cases.

Age.	Boys.	Girls.	Total.
1— 4	3	2	5
4— 6	2	3	5
6—10	16	45	61
10—15	30	88	118
Total . . .	51	138	189

Hughes, 100 Cases.

Age.	Boys.	Girls.	Total.
1—10	11	22	33
10—15	11	34	45
15— ?	5	17	22
Total . . .	27	73	100

Lewis Smith, 1471 Cases.

Years.	No.
1— 6	121
6—10	855
over 10	238
466 Boys.	
1,005 Girls.	

Sée, 191 Cases.

Years.	No.
1— 6	11
6—10	94
11—15	57
15—21	15
21— ?	12

What then are the underlying anatomical and physiological conditions of infancy and childhood which cause this peculiar irritability of the nervous system which displays itself preëminently in motor phenomena. It may be replied that these are:

I.—Growth.

II.—The comparatively large development of the nervous system and its imtimate relation to the rest of the body.

III.—The predominance of reflex action over voluntary.

IV.—Unstable condition of nerve elements.

V.—Peculiarities of the circulatory system.

FIRST CONDITION:—*Growth.*

In the earliest condition of the embryo, as in the protozoa, there is growth without the presence of a distinct nervous system; "nervous and non-nervous elements are chaotically mixed." Embryologists have been indefatigable in their researches, and thanks to their investigations, the panorama of the development of the nervous system to the time of birth is more or less clearly unfolded. They have shown how the primitive streak gives place to the medullary groove, with its increasing layers of epithelial cells; how the medullary groove becomes a simple epithelial tube, from whose walls are to be developed the nerve centres, including the complex cerebrum, with its basal ganglia, nerve nuclei, and intricate tracts of connecting nerve-fibres; how the tube bends, the cephalic portion expands into the cerebral vesicles; how the cerebro-spinal ganglia are pushed out from the central nervous system, as are also those of the sympathetic; how delicate nerve fibres are developed which are to unite the medullary tube with the surrounding parts and to connect the dorsal portion of the nervous axis with the sensory organs, which are developed from the epiblast—the ventral with the motor organs, the muscles, which are developed from the mesoblast; how in the fourth to the sixth week the anterior and posterior horns appear; how, at the third month, and becoming substantially complete at the fifth month, the principal groups of motor cells of the anterior horns have become differentiated from the surrounding embryonic tissue. These groups, which, according to Ross, are the first to attain the dignity of processes, preside over fundamental actions which are carried on in a reflex manner, and are in a great measure independent of the cerebral ganglia, while the median cells belong to the so-called accessory system since they preside over special and skilled movements, and at the birth of the child are less developed and less formed then afterward.

Aristotle divided life into three epochs: 1. Growth, including infancy and childhood; 2. Maturity; 3. Decline. Growth is the crowning distinction of the anatomical, physiological, and pyschical conditions of early existence in contrast to those of the adult. The consideration of the anatomy and physiology of this Aristotelian epoch would, with its almost daily changes, require a daily record from the moment of birth to puberty. The new-born infant passes through, in the first five or six months, a well-marked period, "the first epoch of transition," after which comes the perilous time of first dentition, extending through the second year. These two constitute the period of "infancy." The four or five years succeeding are called "the epoch of transition," which in turn is followed by the period of second dentition, including the years from eight to fourteen. During all this time, now slowly, now more rapidly, the mysterious process of growth is silently, yet ceaselessly, going on, transforming as by a miracle the puling, helpless infant into the round and rosy child, and the round and rosy child into the vigorous and comely youth of goodly proportions. It adds weight to the body, increasing it in length, breadth, and thickness. Each organ of the body participates in the growth. The microscopical elements are both enlarged individually and multiplied in number. For instance, the muscle, according to Budge, becomes thicker through the broadening, as well as through the addition to the number of muscular fibres.

Nowhere is the process of growth more rapid than in the nervous system. The growth of the brain is unparalleled anywhere else in the body. It has been likened to that of the pregnant uterus. The weight of the cerebrum is doubled in the first two years, and it reaches nearly its maximum[1] at the end of seven years, after which its growth is slow. With this rapidity of growth development of function is going on. Thus the triple process of growth, nutrition, and function takes place at the same time, in the centres which preside over the nervous system—conditions which prevail in other parts of the body as well. It would take a long chapter to set forth all the variations and fluctuations of growth, and to show the ingenious tabulations[2] to display its relation to cell and fibre, to tissues and combinations of tissues into organs; but certainly it cannot be doubted that it stands intimately related to the peculiar pathological manifestations and the singular irritability of the nervous system of the infant and child.

SECOND CONDITION:—*The comparatively large development of the nervous system and its intimate relation to the rest of the body.*

According to the tables of Vierordt, the relative weight of the nerve-centres is far greater than in the adult. The brain is 14.34 % of the body-weight, while that of a full-grown person is 2.37 %. "The vital unit" is more strongly characterized, and the functions have a greater reciprocal dependence; consequently any disturbance in any part of the system destroys the nervous equilibrium. Says Ross: "The nervous system is a mechanism by which all the actions of the individual are brought into relation with one another and with the action of external agents upon the organism. Disease of the nervous system is indicated objectively by a loss of harmony between the various actions of the individual; hence arises a disturbance of the motor function or the kinesio-neuroses. How easily this loss of harmony is brought about in early life is illustrated by the slight causes which produce convulsions—undigested food in the stomach, irritation of the intestinal tract, the process of cutting a tooth. Each, as is well known, may bring on a paroxysm."

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[1] Sigmund Fuch's (Litzungs ver der Akad d. Wissensch. in Wien, 1883) states that the brain of a new-born child possesses no tracts of medullated fibres neither in the central nor cortical portions. During the seventh and eighth year the medullated fibres reach the disposition which they preserve throughout adult life. He says we may assume that these chronological differences in the development of the medullated fibres correspond to their physiological interpretation.

[2] These have been gathered together by Vierordt in his "Physiologie des Kindesalters," *loc. cit.*

Table[1] showing the changes which occur in the organism from birth to adult life, in the weight of the various organs in the percentage of body-weight:

	New-Born.	Full Grown.
Skeleton	16.07	15.35
Muscles	23.04	43.09
Skin	11.03	6.03
Brain	14.34	2.37
Spinal Cord	0.20	0.67
Eyes	0.28	0.023
Lungs	2.16	2.01
Heart.	.89	.52
Thymus	.54	0.0086
Stomach and intestines	2.53	2.34
Pancreas	0.12	0.15
Liver	4.39	2.77
Spleen	0.41	0.346
Supra-renal capsules	0.31	0.014
Kidney	0.88	0.48

THIRD CONDITION:—*The predominance of reflex action over the voluntary.*

The infant and young child may be compared to Goltz's frog, which, when its cerebrum was removed, executed coördinate movements if external stimulus was applied. If thrown into water he would swim, if stroked he would croak rhythmically. In much the same way the infant draws its first breath when its sensitive skin comes in contact with the air; so it smiles or weeps when played upon by pleasurable or disagreeable sensations. The brainless frog and the infant are machines: the first nothing more; the second a machine, now imperfectly, but as time goes on and the higher centres with their connecting nerve-paths are developed, to be more or less completely governed and checked by the will. Meynert has shown that motions are produced in two distinct ways, according as the impressions travel through two distinct paths: the reflex path, which is complete at birth; and the paths from cortex to periphery, which are not then developed,

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[1] "Grundriss der Physiologie," fifth ed., p. 605.

Soltmann's experiments on new-born puppies beautifully demonstrate the gradual development of the voluntary paths. He found that it was not until the tenth day after birth that the fore paws moved in response to electric irritation of Hitzig's cerebral areas. On the sixteenth day two other centres were discovered, one for the hind paw and one presiding over the facial muscles. He has also demonstrated that the inhibitory centres (Setzchenow's) do not exist in the new-born. He reasons, therefore, that an irritation of the gray substance meets no resistance, there is no obstacle to be overcome, hence an impulse travels unhindered through the motor channels.

Obscure and difficult experiments however interesting and instructive are not necessary to demonstrate that it is very gradually that the will obtains its control. The fond and delighted mother sees the unskilled and purposeless movements of her babe give place to those of ease and grace. Little has she realized the structural preparation which has been going on; how round cells without membrane have given place to caudate cells with a membrane; how the caudate cells, with their few processes, develop as their relation becomes more complex, a greater number of processes keeping pace with the functions, as they advance from actions diffused and simple to those which are well defined.

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[1] Soltmann: Exper. Studien über die Funktionen des Grosshirnes der Neugeborenen. *Jahrb. f. Kinderheiekde*, 1875, IX., 106.

The physical basis of the mind offers a vast theme for speculation and scientific adventure. We build our theories of the how and the wherefore to-day, and see stretching before the future anatomists and physiologists of both the unfolding and developed organism, an immense labyrinth of knowledge into which he will be led by the slender threads of hypothesis and theories of the present.

It is readily seen that the influence of the will upon the nervous system is exceedingly small in early infancy; and only gradually developed during the period of childhood, at no time attaining such control as in the adult; but the lower centres are well-nigh perfectly developed, so that reflex action unchecked by the cerebrum forms the crowning characteristic of nerve force. As it has been expressed: there results a radiation of impulses since the will is less centralized and isolated into neighboring paths resulting in a more or less involvement of voluntary muscles.

FOURTH CONDITION:—*Unstable Condition of Nerve Elements.*

The nerve elements consists of ganglion cells and conducting fibres. The physiologist says that a nerve impulse gives rise to no visible alteration of form, but transmits along with itself certain molecular changes set up by the stimulus. The most advanced theorizers in regard to nervous functions think that there can be little doubt that nerve irritability depends upon the fact, that the protoplasm of the axis-cylinder is composed of molecules in unstable position, and that these are so connected that the movement or alteration of one leads to the movement or alteration of those in the immediate neighborhood. In other words all nervous phenomena depend on molecular oscillations and chemical changes.

The physical and chemical peculiarities of the tissues of early life are comparatively little known.[1] It is well recognized that they contain much more water,[1] which increases the weight of the organs and tissues, notably the muscles, liver, and brain ; it also increases their delicacy, and so the partitions separating structure from structure are much thinner, consequently the endosmotic interchange takes place much more readily than in the adult. Metabolic processes are much more extensive and more rapid than in the full-grown.

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[1] Vierordt: "Physiologie des Kindesaltes," *loc. cit.*, p. 389.

As a physiological result the nervous system is much more responsive to stimuli. The molecules, according to one of the axioms of the molecular theory, require less force to move them, the greater the departure from the solid form. The same rule applies to chemical action. *Corpora non agunt nisi sint soluta* was the maxim of the ancient chemists. Therefore this watery, pulpy condition of the tissues must be an important factor in the neuroses of childhood, facilitating as it does the molecular and chemical changes incident upon the generation of nervous impulses.

FIFTH CONDITION :—*The Circulatory System and its Peculiarities.*

The amount of blood on account of the great activity of the organs is much greater in proportion in the infant and child than in the adult. It circulates with greater rapidity, coursing through the whole body in 12.1 seconds in the new-born, 18.6 in the youth of fourteen, and 22.1 in the adult.[2] The large amount and rapidity of the circulation predisposes to inflammation and congestion of all the organs, which may react indirectly on the nervous system, because of the close relationship of the various parts of the organism of the child already alluded to ; or it may act directly, causing inflammation of the brain itself or of its meninges.

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[1] Molleschott estimates that 68 % of full-grown human body is water ; Fehling gives that of the new-born as 74. 4 %.

[2] Vierordt : *loc. cit.*, p. 314.

The skull with its distensible fontanelles and unossified sutures taken together with the softness of the brain-substance permits extensive variations of cerebral circulation in the infant. The quantity of blood can be greatly increased or correspondingly diminished. Another mechanism which checks the too violent entry of the blood into the brain of the adult is not perfected in the child if the statement of Moxan in one of the Croonian lectures[1] is to be relied upon. He says:

"When the heart acts violently (that is, in the adult) the choroid plexus becomes distended and the finger-like cornu of the fourth ventricle, which contains the blood-vessels of the choroid plexus, becomes distended and presses on the root of the vagus and so moderates the heart's action. It is a contrivance like the ball-tap of a cistern." In early life, as has been said, the connection of these parts is not made.

Soltmann's experiments on new-born animals prove that a more powerful irritation of the vagus is necessary before the changes are as great as in the adult.

Experience shows that the heart's action is rapid and irregular, and theory and experiment coincide in attributing its rapidity to the imperfect development of the inhibitory apparatus. The vaso-motor centres are very responsive, as illustrated by the quick blushes of the child when under the influence of mental emotion. But vaso-motor variations, and other peculiarities of the blood, such as its morphological structure[2] and chemical composition[3]; the influence of blood pressure, are obscure points which need further elucidation, but doubtless have effects which, if they were known, would go a great way toward explaining the problems of the neuroses. The plethoric and anæmic theories of epilepsy advanced by Henle, Schroeder van der Kolk, Echeverria, and Meyer, are well known; combined excitation of the vaso-motor and convulsive centres, according to Nothnagel, is the necessary pathological condition; while Kussmaul and Tenner have shown that epileptic convulsions are produced by rapidly depriving the brain of blood. Kirk has pointed out the part that embolism plays in chorea, and Hughlings-Jackson advances the same views. "We see, in chorea," says Dr. Dickinson, "a widely distributed hyperæmia of the nervous centres not due to any mechanical mischance, but produced mainly by causes of two kinds: one a morbid, probably a humoral, influence which may affect the nervous centres as it affects other organs and tissues; the other, irritation in some mode, usually mental, but sometimes what is called reflex, which especially belongs to and disturbs the nervous system, and affects persons differently according to the inherent mobility of their nature."

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[1] Influence of circulation on Nervous System. Croonian Lectures for 1881. *Jour. of Ment. Sc.*, Oct., 1881.

[2] Moleschott has found that the proportion of red blood corpuscles is relatively greater in the child.

Arnheim (*Jahresbuch f. Kdhlk.* 1879, xiii. 293) found an average of 4½ million corpuscles to the c. m., half a million less than the adult.

[3] Hæmoglobin is very abundant in the first weeks of life, then decreases till the sixth year, again to increase and reach a maximum at fourteen. Leichenstern: "Untersuch. ueber den Hæmoglobulin gehalt des Blutes." Leipzig, 1878. Quoted by Vierordt.

However, it is not the purpose of this paper to enter into the discussion of the multitudinous theories which have been brought forward to explain the kinesio-neuroses; but these have been cited to show that the extensiveness of the influence of the blood and circulation upon the irritability of the nervous system is appreciated by those who have occupied themselves with the subject.

Given, then, a nervous system rendered peculiarly liable to disease by reason of rapid growth; greater development in comparison to other tissues of the body; less under the guidance and inhibition of the highest nerve-centres, and peculiarly liable to reflex action; its nerve elements unstable; a circulation rapid and less under control, it is not surprising that among the diseases of childhood those of the nervous system take a foremost rank. For the reason just stated, all those causes which are instrumental in producing nervous affections in general act more readily upon the susceptible nerve elements of early life, such as the influence of heredity, shocks to the nervous system, fright and terror, the peculiar effects of example, which have caused epidemics of chorea as well as hysteria; derangements, local and constitutional, which result in convulsions in a child, and in a rigor or delirium in the adult.

The reasons why the neuroses of infancy and childhood should be motor rather than sensory have already been indicated. They may be summed up as follows:

1. The reflex arcs, of which the motor strands form an important part, are earliest perfected, so that when a sensory stimulus sets free nerve energy, it is liable to overflow into motor paths.

2. Intellectual comprehension of sensation, and, consequently, of pain, is the last to be developed; in consequence, severe nervous shocks, which would give rise to exquisite pain in the adult, result in a kinesio-neurosis in a child.

It must not be lost sight of that the periods of infancy and childhood embrace a wide range of conditions. The four epochs of first and second transition and of first and second dentition vary from each other in many striking respects. A state of continued progression and development is going on,—a continued series of changes of anatomical, physiological, and psychical events, with which the manifestations of disease keep pace, and by which they are modified.

In early infancy it has been shown that the simple kinesio-neuroses prevail,—infantile trismus, inward fits, the rare disease of salaam convulsions, eclampsia. Later the eclampsia of the child gives place to the more complex disease of epilepsia, epilepsia, the acute disease of eclampsia, which has become chronic. In very young children the curious sensory phenomena which characterize the *aura epileptica* is less marked; that and the cerebral symptoms become more prominent as the years advance. Chorea, which is a psycho-motor neurosis, rarely occurs before the age of six. Hughlings Jackson says: "Since the disorder in chorea is of movements which are acquired and which are probably only fully learned by a long apprenticeship, I used to suppose that the nervous arrangements for these movements were but partially developed in children, and that the motor processes involved and their arterial integration would be, so to speak, caught in the stage of incomplete development, —in short, their centres were diseased when half educated."

As every one knows, the great weight of the disease falls upon the muscles, and the motor manifestations range through all degrees, from the slight twitchings of chorea minor to the general chorea in which the body undergoes every variety of muscular contortion, meriting thereby the descriptive epithet of Bellingham, "insanity of the muscles," or that of Bouillaud, "*folie musculaire.*" While the relation between chorea and hysteria is not so clearly manifest as that between eclampsia and epilepsia, yet there are sensory and psychical disturbances occurring in chorea which make it easy to see that the choreic child may become an hysterical young person. Sometimes nervous disease is precocious in the child, and hysteria develops early. Briquet speaks of it appearing under the age of ten in one eighth of his cases; but, as a general thing, hysteria is not seen till the period of growth merges into that of maturity and the pathological development of the neuroses has followed the anatomical and physiological, the result of which is a complex disease of the entire nervous system, affecting motility, sensibility, circulation, nutrition, and the psychical life.